

### 3D-LAUE MICRO DIFFRACTION TO CHARACTERIZE FATIGUE DAMAGE IN BI-CRYSTALLINE MICRO CANTILEVERS

Jean-Baptiste Molin, Max-Planck-Institut für Eisenforschung GmbH  
j.molin@mpie.de

Loïc Renversade, Univ. Grenoble Alpes, INAC / CRG-IF BM32, ESRF

Olivier Ulrich, Univ. Grenoble Alpes, INAC / CRG-IF BM32, ESRF

Odile Robach, Univ. Grenoble Alpes, INAC / CRG-IF BM32, ESRF

Jean-Sébastien Micha, Univ. Grenoble Alpes, INAC / CRG-IF BM32, ESRF

Christoph Kirchlechner, Max-Planck-Institut für Eisenforschung GmbH

Key Words: 3D-Laue diffraction, fatigue, grain boundary.

Laue microdiffraction ( $\mu$ Laue) – a synchrotron based technique applying sub-micron sized ( $0.5 \times 0.5 \mu\text{m}^2$ ), polychromatic x-ray beams – has proven to shed unprecedented light onto the deformation behaviour of small volumes. So far,  $\mu$ Laue was used *in situ* as well as for 2D mapping to understand the tensile, compression and fatigue behaviour of metals. 3D- $\mu$ Laue – also called “Differential Aperture X-ray microscopy” [1] – extend the capabilities of  $\mu$ Laue to achieve submicron 3D spatial characterization. An absorbing wire is moved between the sample surface and the detector. It is used to partially shadow the Laue pattern in order to reconstruct depth-resolved Laue patterns (see Fig.1). The achieved depth-resolution is in the order of  $0.5 \mu\text{m}^3$ . In recent years we have adopted the 3D approach and coupled it with an *in situ* deformation rig.

In this work we present the *in situ* characterization of low cycle fatigue damage in focussed ion beam (FIB) milled, micron sized copper single and bi-crystalline cantilevers ( $5 \times 5 \times 25 \mu\text{m}^3$ ). Each bi-crystalline sample contains one single grain boundary located at the neutral plane. The experiments were performed at BM32 of the European Synchrotron (ESRF), using a combination of a micro straining rig and 3D- $\mu$ Laue. From the measurements the lattice orientation, deviatoric strain tensor and the density of unpaired dislocations are extracted with sub-micron resolution. This is done at several different deformation stages, i.e. after  $\frac{1}{4}$ ,  $\frac{1}{2}$ ,  $\frac{3}{4}$  and full cycle.

In the talk we will discuss the cyclic dislocation accumulation in the vicinity of and at single grain boundaries with superior spatial resolution, which is a pre-requisite to thoroughly understand fatigue damage initiation at grain boundaries.

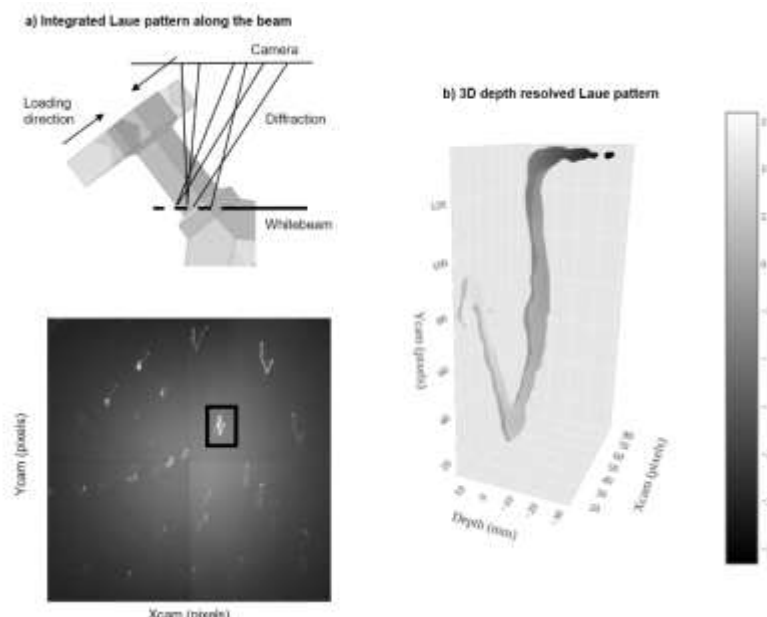


Figure 1 – a) Laue pattern of a deformed  $10 \times 10 \times 25 \mu\text{m}^3$  micro cantilever and b) the depth-resolved reconstruction of one peak.

[1] B.C. Larson et al, Three-dimensional X-ray structural microscopy with submicrometre resolution, Nature, 415(6874) (2002) 887-890.